Report No. FAA-RD-77-71

AD A043859

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B.S.

DEVELOPMENT OF A FRANGIBLE APPROACH LIGHT

JAMES N. USKO

SEPCO DIVISION
Connecticut International Corporation
Windsor Locks, Connecticut 06096

MARCH 1977

FINAL REPORT

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Prepared for

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
Systems Research & Development Service
Washington, D.C. 20590

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16. Abstract

This document describes the effort expended by Connecticut International Corporation in fullfillment of Contract DOT-FA-75WA-3610 to develop a lightweight, frangible approach light housing. The program demonstrated that the goal of frangibility was not achievable as initially concepted. However, significant progress has been made in the state of the art relative to housings which are lightweight, suitable for the visual aid purpose intended, and with a substantial measure of frangibility.

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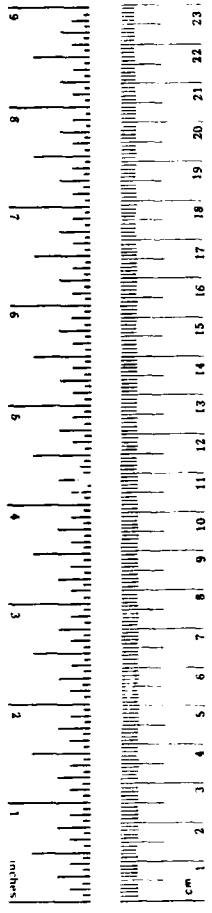
METRIC CONVERSION FACTORS

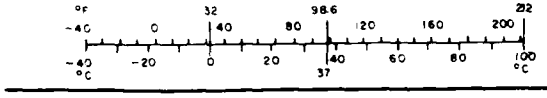
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



Preface

This effort is significant in light of the overall concern by the FAA to improve the safety of landing aircraft. This program, together with related contracts on lightweight, frangible support structures should provide the FAA with the technology to greatly diminish the risks to landing aircraft which presently exist.

The Connecticut International Corporation acknowledges the technical assistance of Messrs Bret Castle and Leon Reamer at NAFEC in the performance of tests on this program.

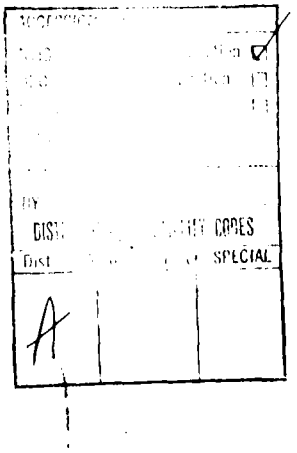


TABLE OF CONTENTS

TABLE OF ILLUSTRATIONS

APPENDIX:

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1. PURPOSE: The purpose of this contract was to design, develop, and deliver a light weight, low impact, High Intensity Approach Light. The fixtures were designed to be pole mounted on 1" EMT and used on a standard approach light system. The fixtures were to be designed to have a frangibility requirement that the assemblies would not penetrate the windshield of a CESSNA 172 when hurled perpendicular to the surface of the windshield at speeds up to 75mph (120 Km/hr). Instead, the unit would fracture. This requirement was imposed together with environmental conditions of -55°C to +55°C, up to 95% humidity, Salt Spray, Thermal Shock, and Jet Blasts of up to 350mph (560Km/hr). The total weight of the unit with filter and lamp was to be less than 3 pounds (1.4 Kg.). Consideration of low manufacturing costs was a primary requirement.

2. BACKGROUND: These fixtures were to be designed to fracture and absorb energy upon impact to minimize damage to both aircraft and occupants. To accomplish this there were two design concepts originally to be investigated. Concept 1 was to design a housing that would hold a PAR56 lamp with penetrators that would sense the impact of the aircraft on the Lamp Housing, and then fracture the lamp. Concept 2 was to design a housing with a foam material for an inner core with an outer skin that would protect it from the environment, in this concept the foam material was to absorb the impact of a collision and prevent the lamp from doing damage. Both concepts will be discussed with advantages, disadvantages, and problems encountered with the design, which led to the final design of the approach light. The final configuration, while using the information resulting from the two contractually suggested requirements, was in fact a formulated plastic blend to simultaneously achieve the frangibility, temperature, and jet blast requirements.

3. CONCEPT 1 The penetrator approach was to construct a housing of a light weight material which was to house a PAR 56 lamp. The housing was to have a simple leveling mechanism that would clamp to 1" EMT. The outside of the housing was to be smooth, while the inside of the housing was to have grooves to add to the frangibility. For this concept, a drop test was performed to see what energy level was required to break a PAR 56 lamp so a penetrator and trigger mechanism could be designed. This test was performed on standard lamps and on lamps that had been through an annealing process. See table 1 for results.

TABLE 1

Lamp No	Lamp Description	Energy req'd to fracture lamp
1	Annealed	184 in-lbs ,(2.1 m-Kg)
2	Annealed	144 in-lbs,(1.65 m-Kg)
3	Annealed	168 in-lbs,(1.92 m-Kg)
4	Not Annealed	320 in-lbs,(3.6 m-Kg)
5	Not Annealed	256 in-lbs,(2.9 m-Kg)
6	Not Annealed	242 in-lbs,(2.8 m-Kg)

It can be noted from the table above that the annealed lamps offer an advantage of frangibility. Although the annealed lamps required less energy to break, the process of annealing adds the disadvantage of the lamps loosing its ability to withstand thermal shock. Since these lamps were required to be exposed to an environment susceptible to thermal shock this portion of the design using the annealed PAR 56 lamp was discontinued and the design proceeded with the standard PAR 56 lamp.

For the trigger mechanism to work, it would be necessary for the mechanism to sense the impact, release the trigger, and fracture the lamp before the aircraft's windshield could be impacted sufficiently to cause damage.

Assuming that such a sensing device could be mounted on the filter holder, or other similar arrangement, we can calculate the time available for the trigger. Using the classical formula

$$s=Vt \qquad \text{(acceleration assumed to be 0)}$$

we can find t for say a sensor located 3" in front of the lamp.

$$t=\frac{s}{V}=\frac{3''}{75mph}=2.27\ ms.$$

Therefore, all of the above actions required of the trigger mechanism i.e. accelerometer or other sensor response, release time of actuator and time for the actuator to move from its rest position to the lamp, and lamp fracture time must take place within the 2.27 ms time area.

Studies were made to determine the practicality of the above, and it was concluded that it was not practical to design a high speed trigger mechanism which would react in time while not adding to the safety hazard at impact, and itself being impervious to accidental triggering in service or during normal relamping. Therefore, the penetrator approach was discarded.

4. Concept 2: In this approach the housing material was to have a foam inner core with a hard outer skin, with the housing protruding in front of the lamp. This material was to absorb the impact before the lamp came in contact with the airplane.

A further extension of this concept, which became the final design, was to have a material which in itself was frangible and would fracture on impact. Due to the varying angles of impact, it was determined to be impractical to design the geometry of the holder to impart a vector of energy to the lamp tangential to impact, thus "avoiding" the lamp-windshield collision. The limit of frangibility, therefore, was determined to be that of the bare lamp. Tests showed these would break the windshield of a Cessna 172 at approximately 40mph (65 Km/hr.).

A chemical/plastics consulting firm, Debell & Richardson, Inc. of Enfield, Conn., was engaged as a subcontractor to develop a suitable material. Their efforts resulted in two prototype concepts, one using urethene foam material and one with a uniform homogeneous mixture of polyester material. It was recommended by the subcontractor not to use the urethene foam material because of its higher production cost over the polyester material.

The above investigation resulted in the design as shown in figure 1.

This concept was then followed into the purchase of tooling and building of several prototypes to figure 1. These prototypes were tested at NAFEC to evaluate its frangibility on impact required by the contract.

The results of the test did not meet the requirements of the contract which were that the complete assembly was not to penetrate the windshield of a "Cessna 172" at a velocity of 75mph (120Km/hr.).

The highest velocity at which the housing and lamp did not penetrate the windshield was recorded at 42mph (68Km/hr.) which is an improvement over the present aluminum design which penetrated the windshield at 25mph (40Km/hr.). At this point of the program, the impact test was evaluated by both FAA and Sepco personnel. Doubts were expressed that any practical unit using a PAR 56 lamp would be capable of meeting the 75mph (120Km/hr.) impact requirement. The results were the following and would be added to a new design.

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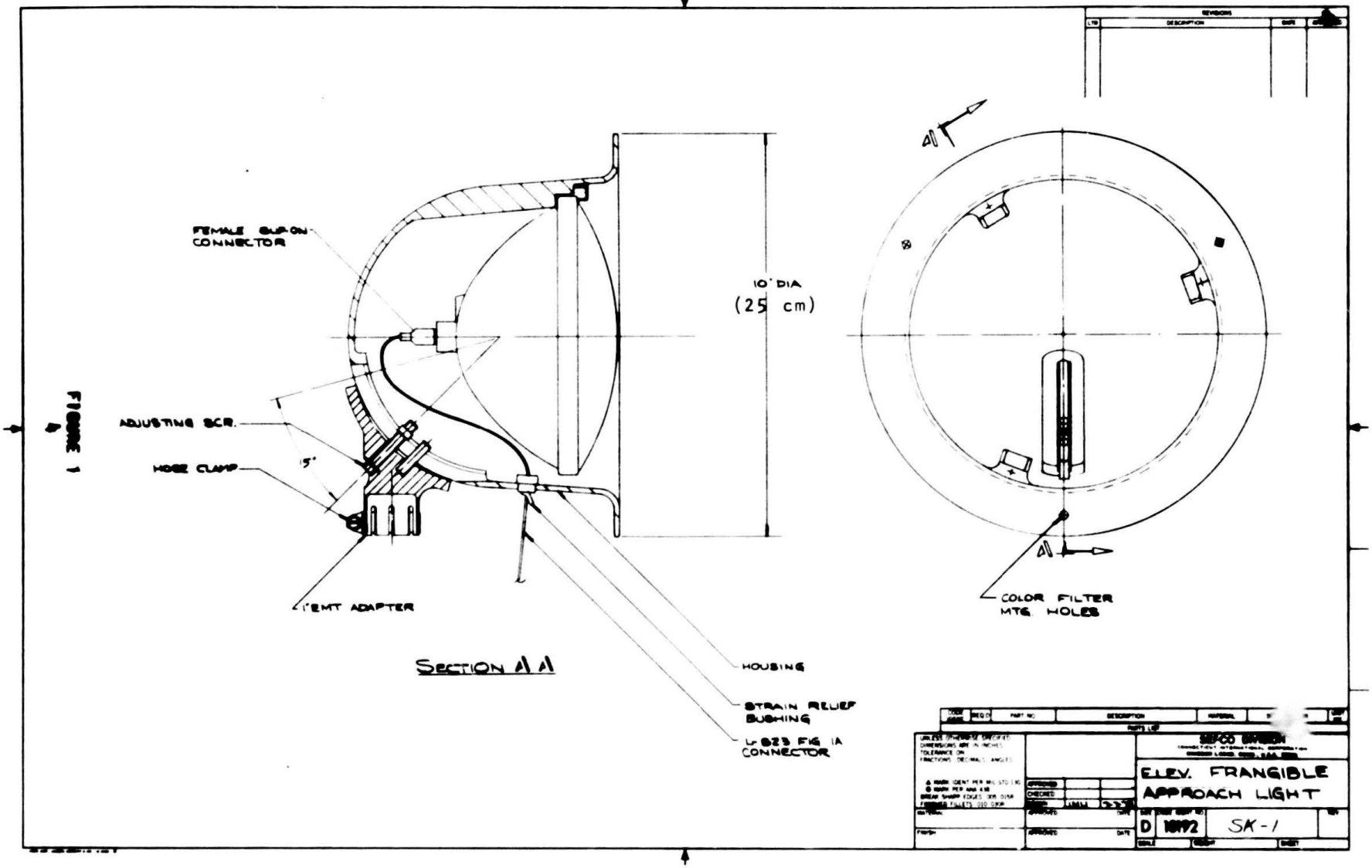

FIGURE 1

1. redesign to a stream line shape and reduce the weight

2. weight of unit without filter to be 2.75 lbs. (1.25 Kg.)

3. weight of unit with filter to be 3.0 lbs. (1.36 Kg.)

4. drop test to evaluate frangibility

5. Perform environmental and photometrics testing per contract.

With this redesign (see figure 2) of making the housing smaller and more streamlined a new problem developed, heat was being trapped on the inside of the housing and was causing the polyester material used in the previous design to over heat. A new material now had to be developed and the result was a high temperature Epoxy.

With the new design the environmental tests were performed at an independent lab, with the photometrics and drop tests performed at Sepco. There were no problems encountered during these tests.

The jet blast test was conducted at NAFEC with one unit. It showed a failure at 280mph (450Km/hr.) of jet blast. The failure occurred on the 1" EMT adapter. With this failure, Sepco designed an aluminum adapter to use as a substitute for the plastic adapter. The testing of the aluminum adapter for jet blast would have caused a significant contract time delay so it was decided Sepco would send (6) six additional light assemblies at no extra cost for the FAA evaluation. Analysis indicated that the aluminum would be satisfactory for the intended purpose.

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LTR	DESCRIPTION	DATE	APPROVED
A	ADDED PART ORDERING SYSTEM & UPDATED PARTS LIST	3-31-76	
B	ADDED ALUM ADAPTER W/ OPTIONAL PLASTIC ADAPTER		

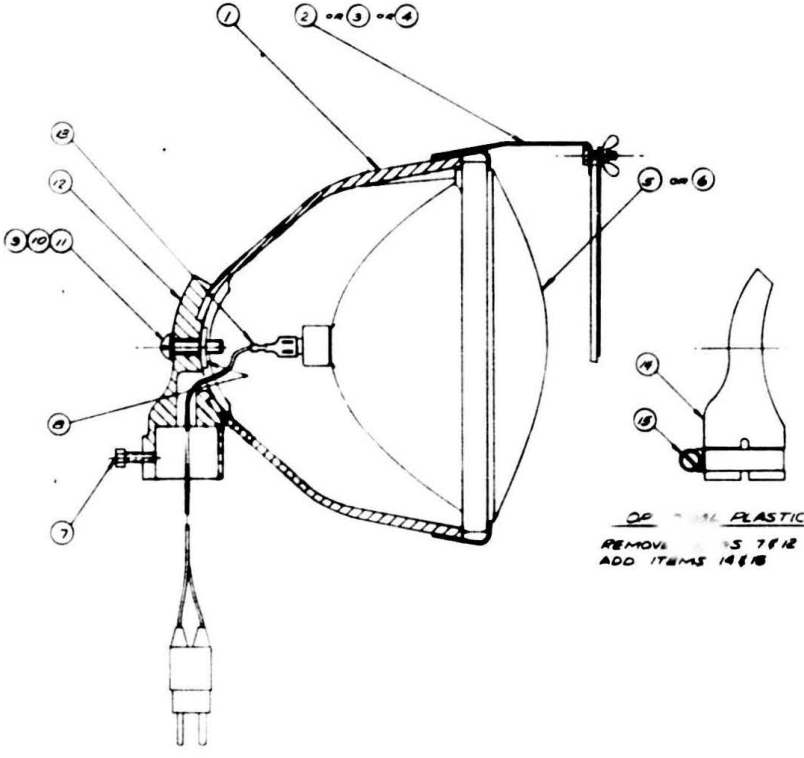

FIGURE 2

OPTIONAL PLASTIC ADAPTER

REMOVE ITEMS 5, 7 & 12
ADD ITEMS 14 & 15

PART No ORDERING SYSTEM

40740 - ( )

BASIC PART No — COLOR REQ'D
C = CLEAR
G = GREEN
R = RED

			ITEM	PART NO	DESCRIPTION	MATERIAL	SPECIFICATION
/	/	/	15	10037-189	HOSE CLAMP	SST	
/	/	/	14	40798	ADAPTER	PLASTIC	
					OPTIONAL PLASTIC ADAPTER		
/	/	/	13	40780	LEAD ASS'Y		
			12	40788	ADAPTER	ALUM	
			11	10030-73	FLAT WASHER #8 DIA	SST	
			10	10030-5	LOCK WASHER #8 DIA	SST	
			9	10080-	SCR RD HD SLOTTED	SST	#8-32
/	/	/	8	40748	NUT	ALUM	
2	2	2	7	10000-8324	SCR HEX HD	SST	10-32
/	/	/	6	40671-648	LAMP 300 W		SEE 40740 PARTS LIST
/	/	/	5	40671-600	LAMP 300 W		SEE 40740 PARTS LIST
—	—	/	4	40799-R	RING ASS'Y & FILTER		RED
—	—	/	3	40799-G	RING ASS'Y & FILTER		GREEN
—	—	/	2	40797	RING ASS'Y		
/	/	/	1	40798	HOUSING	PLASTIC	

CONNECTICUT INTERNATIONAL CORPORATION

ELEV HIGH INTENSITY APPROACH LIGHT

SIZE	CODE IDENT NO.		REV
D	18192	40740	5

SCALE — WEIGHT — SHEET

40740

5. RESULTS: Even though the original frangibility and jet blast requirements were not met, the results of this program has produced a low impact resistant PAR 56 lampholder, and if impacted by a low approaching aircraft, this lampholder will reduce the damage to the aircraft over the existing aluminum lampholder. The housing developed in this contract not only will fracture upon impact but the entire lampholder has less mass and smaller profile dimensions when assembled compared to the present housing, which will prove helpful in mounting on frangible towers by reducing damage to an aircraft upon impact and by reducing wind loading on the towers.

In reducing the weight of housing and keeping the mass to a minimum, it was helpful to use 1/8 inch thick heat resistant glass for coloring the main beam, over the present filter similar to FAA drawing A-4885-1. Also helpful was using two insulated female slip-on terminals that were rated for 20 ampere service over the existing lamp connector that is similar to the FAA C-5407-1.

The Frangible Approach Light developed on this contract had passed all the environmental requirements as noted in Exhibit A of this contract, but with the frangibility requirements also integrated into the design, it cannot be expected that these lampholders will withstand the environment of the existing aluminum housing which were designed to withstand extreme abusement.

In developing of the plastic housing with a 500 watt lamp installed, extreme heat was noted, with the highest temperatures at the top of the housing under the lamp seat. The temperature measured at this point was 302°F (150°C) rise above ambient. In future designs it would be helpful to decrease this heat by adding ribs or venting to the housing to decrease the heat inside.

Below is the drawing list for all parts used to produce this Frangible Approach Light.

Drawing Number	Description
40739	Housing
40740	Elevated Approach Light Assembly
40741	Ring
40742	Adapter - Aluminum
40743	Nut
40744	Ring & Filter
40745	Filter Holder
40750	Lead Assembly
40771	Ring Assembly
40759	Filter Retainer Ring
40760	Filter
40761	Bracket
40798	Adapter Plastic
40646	Catch, pull down
40608	Strike

6. RECOMMENDATIONS: The existing prototype design could be improved in future development by keeping in mind the following:

A. Some plastic material other than this epoxy should be used for the housing to reduce production costs. A material such as a high temperature phenolic can be compounded to achieve the required performance properties which would be faster and more effective for large procurement production. By properly specifying the frangibility, weight, temperature, performance, resistance to ultraviolet effects and other environmental requirements, but not specifying the material, a less expensive light can be provided.

B. A light weight color filter should be used. The present standard filter is excessive in weight.

C. Due to relatively high temperatures inside the lampholder it is recommended that electrical accessories not be mounted inside the lamp housing.

D. It is recommended that a venting system be considered in future designs.

E. Connector, terminals and associated hardware should be as light weight as possible. Aluminum fittings should be of the light section die-cast type.

Appendix A1

Final Report For

Frangible Approach Light

Test Report 7664

QUALIFICATION TEST REPORT

for

FRANGIBLE APPROACH LIGHT

SEPCO P/N's 40740, 40740 G & 40740 R

FAA Contract DOT FA 75WA-3610 Exhibit "A"

Prepared By: Jim Usko 2-1-77
J. Usko, Project Designer

Approved By: Paul G. Anderson 2-2-77
P. G. Anderson, Chief Engineer

SEPCO DIVISION
Connecticut International Corporation
Windsor Locks, Connecticut 06096

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TABLE OF CONTENTS

1. Objectives

The following test was run for qualification of a frangible approach light to meet exhibit "A" of the FAA Contract DOT FA-75WA-3610 and modifications to this contract. The test was run to the Test Procedure Document #7511 Rev. C.

2. Procedure

This test procedure is comprised of five areas of testing which are:

Para. 3. Photometric Test

Para. 4. Environmental Test

Para. 5. Frangibility Test

Para. 6. Jet Blast Test

Para. 7. Size & Weight Test

3. Photometric Test

This test was conducted at Connecticut International Corporation with the following equipment:

(a) Radiometer Detector Head Model 580-20A

(b) Radiometer Indicator Unit Model 580-11A

(c) Strip Chart Leeds & Northrup, Speed-O-Max H

(d) Ammeter Weston

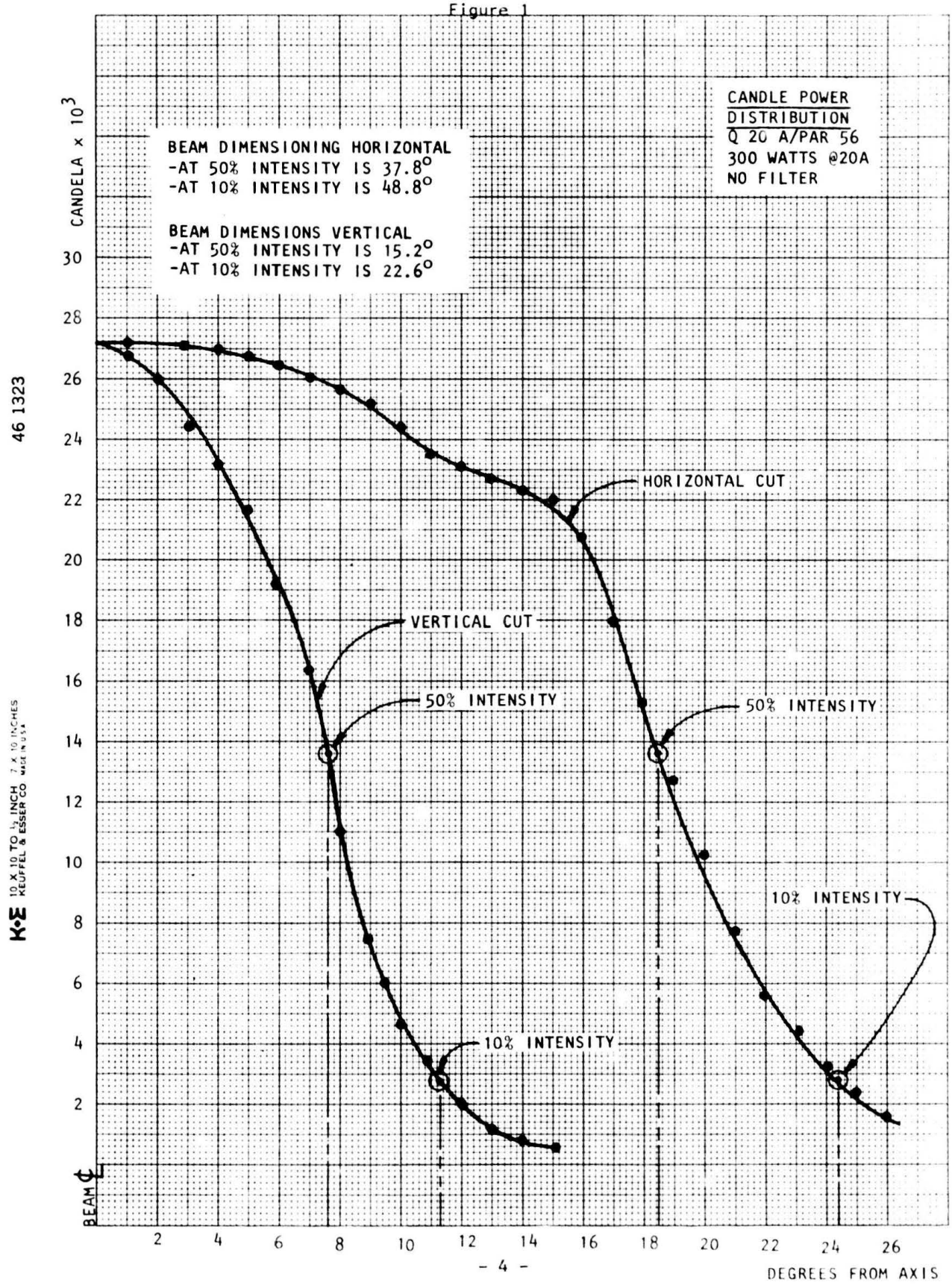
(e) Gonimeter

3.1 This test was conducted in accordance with Document 7511 Rev. C, Para. 3.1. and meets requirements of exhibit "A" of the FAA contract.

3.2 For candle power distribution, see Figures 1 for clear light, Figure 2 for red light and Figure 3 for green light.

3.3 For peak intensities measured, see Figure 4.

Figure 1



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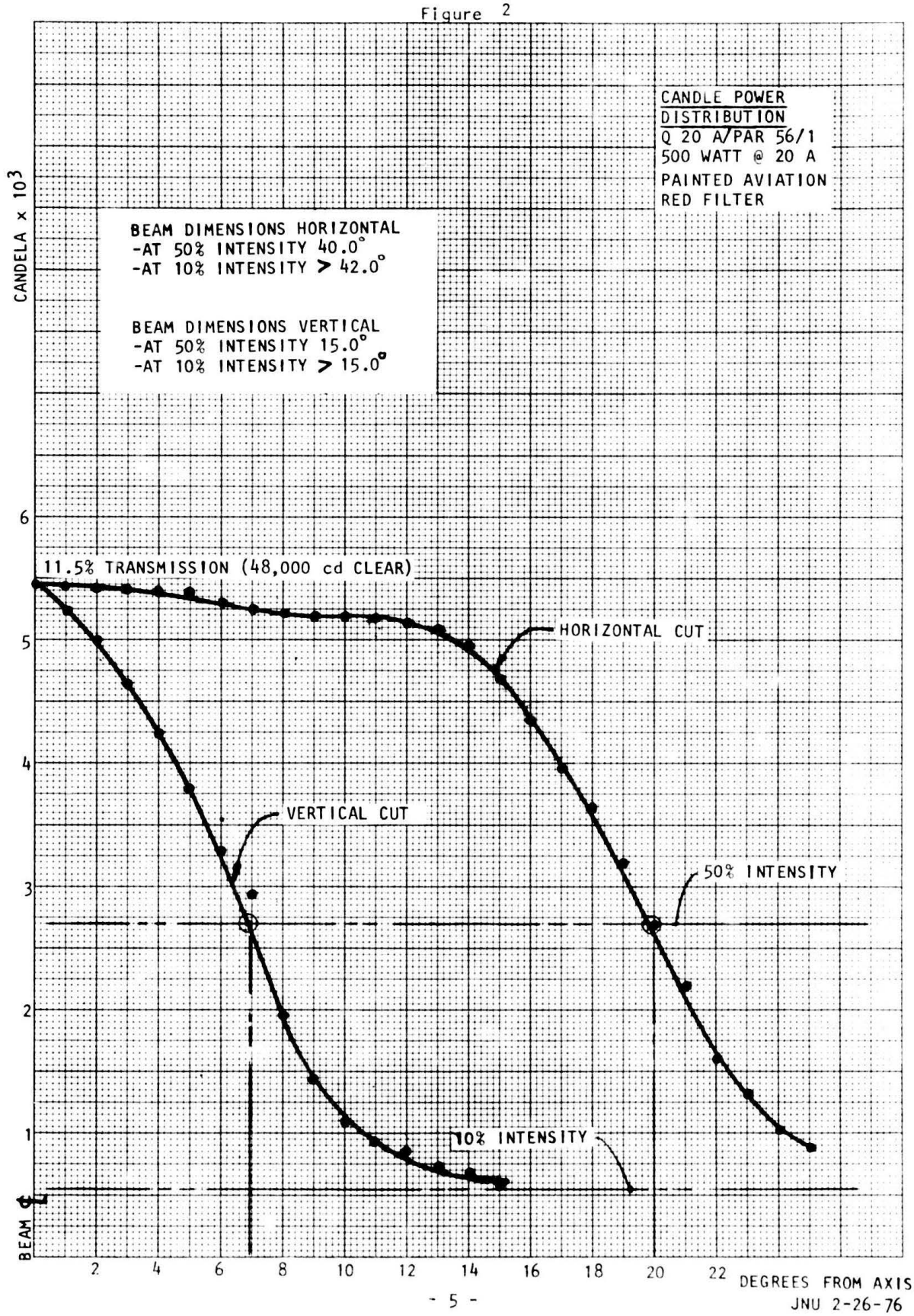
K·E 10 X 10 TO ½ INCH 7 X 10 INCHES
KEUFFEL & ESSER CO MADE IN U.S.A.

Figure 2



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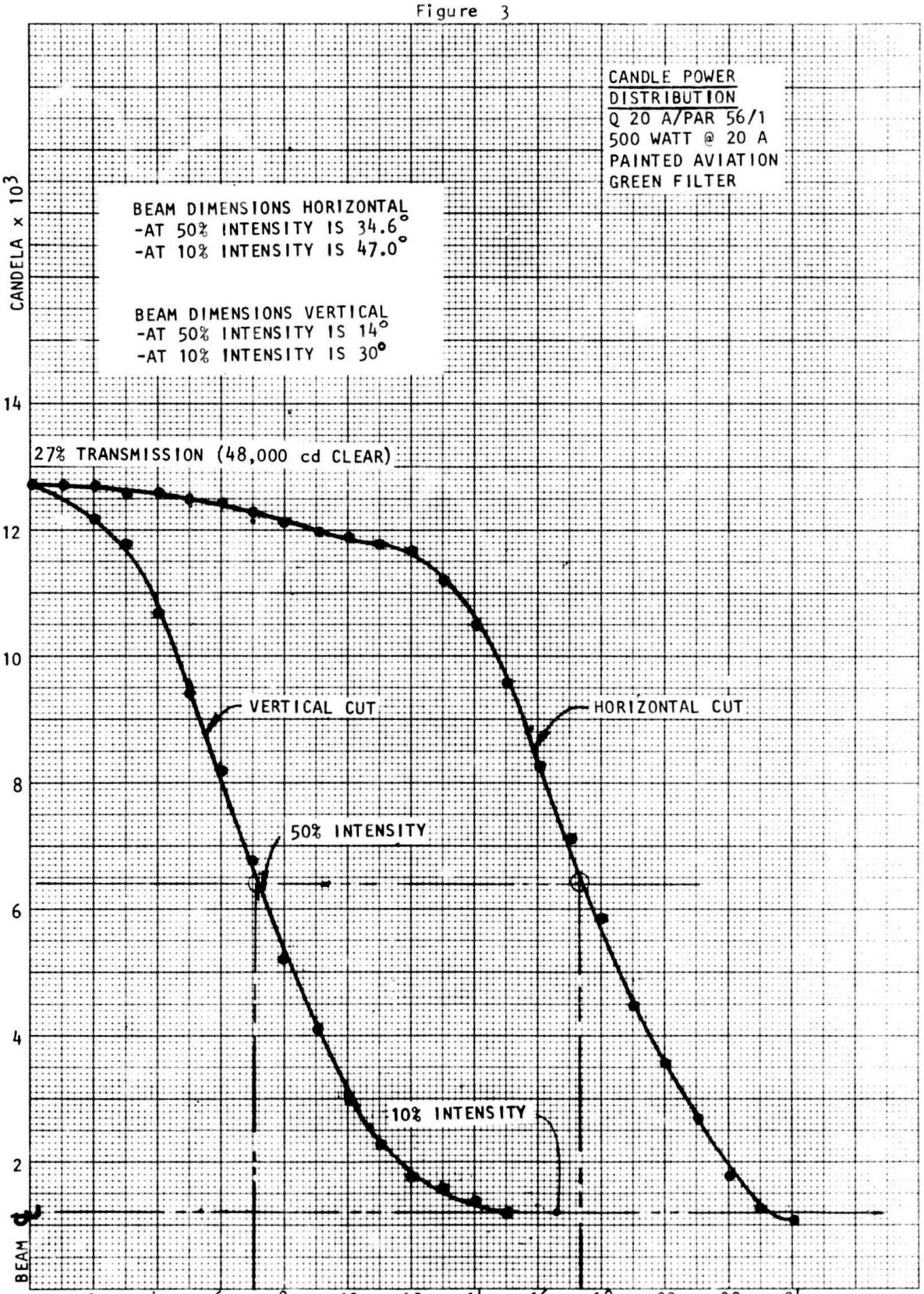
K&E 10 X 10 TO ½ INCH 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A.

JNU 2-26-76

Figure 3



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K·E 10 X 10 TO ½ INCH 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A.

FIGURE 4

300 WATTS CLEAR
27,200 Cd Full Intensity

	AMMETER READINGS				
	20A	15.3A	12.1A	9.9A	8.3A
% Of Full Intensity	100%	20%	4%	.8%	.16%
Intensity (Min.)	27,200 cd	5440 cd	1088 cd	217 cd	43 cd
Measured Intensity	27,200 cd	6440 cd	1600 cd	290 cd	60 cd

500 WATTS GREEN
12,750 Cd Full Intensity

	AMMETER READINGS				
	20A	15.3A	12.1A	9.9A	8.3A
% Of Full Intensity	100%	20%	4%	.8%	.16%
Intensity (Min.)	12,750 cd	2550 cd	510 cd	102 cd	20.4 cd
Measured Intensity	12,750 cd	2700 cd	515 cd	113 cd	23 cd

500 WATTS RED
5450 Cd Full Intensity

	AMMETER READINGS				
	20A	15.3A	12.1A	9.9A	8.3A
% Of Full Intensity	100%	20%	4%	.8%	.16%
Intensity (Min.)	5450 cd	1090 cd	218 cd	44 cd	9 cd
Measured Intensity	5450 cd	1340 cd	334 cd	80 cd	21 cd

% of Full Intensity is from Contract Exhibit "A"

4. Environmental Test

This portion of testing was done at an independent lab, "York Research Corp." For document test report from "York Research Corp.", see Appendix A.

4.1 The Humidity Test was run in accordance with test procedure 7511 Rev. C., Para. 3.4. There was no evidence of corrosion or exterior deterioration and no problems were encountered when illuminating the lamp.

4.2 The Salt Spray Test was performed in accordance with the Document 7511 Rev. C, para. 3.7. Assemblies tested showed no evidence of corrosion or exterior deterioration and no problems were encountered when illuminating the lamp.

4.3 The Thermal Shock Test was run to Document 7511 Rev. C., para. 3.6. There was no evidence of any physical damage as a result of the Thermal Shock Test.

4.4 The Corrosion Test was conducted to Document 7511, Rev. C., para. 3.8. A visual inspection of the assemblies after humidity and salt spray testing showed there was no evidence of corrosion or malfunction of any mechanical parts.

4.5 The High Temperature Test was performed in accordance with Document 7511 Rev. C, Para. 3.3.1. The assemblies functioned normally during the test. There was no evidence of deterioration or malfunction as a result of high temperature test.

4.6 The Low Temperature Test was conducted in accordance with Document 7511 Rev. C, para. 3.3.2. The assemblies functioned normally during the test. There was no evidence of deterioration or malfunction as a result of low temperature test.

5. Frangibility Test

This test was conducted at Connecticut International Corporation in accordance with Document 7511 Rev. C, para. 3.2. The three housings were first dropped from a height of 12 inches (30 cm) and no fractures noted. Then dropped from a height of 36 inches (90 cm) all three had started to fracture. Two pieces had fracture lines 1-2 inches (2.5 - 5 cm) long and one piece had a fracture line approximately 6 inches (15 cm) long.

6. Jet Blast Test

This test was conducted at NAFEC with one unit of Class I (unit with no filter), and was run with the lamp facing away from the jet blast, also mounted on 1" EMT. This test showed the adapter fractured at a point even with the top of the 1" EMT at a wind velocity of 280 M.P.H. (450 Km/hr) the failure was noted by FAA and Connecticut International Corp., and it was agreed to continue contract.

7. Size and Weight

This portion of the testing was done at Connecticut International Corporation in accordance with Document 7511 Rev. C, Para. 3.9.

Profile height of assembly measured to be 7-1/2 inches, (19 cm.) well below the 10 inch (25 cm) maximum height.

The weight of P/N 40740-C assembly with no filter weighed 2 lbs. 9 oz. (1.15 Kg.) complete which is below 2 lbs. 12 oz. (1.25 Kg.) maximum allowable weight.

The weight of P/N 40740-R or 40740-G assembly with colored filter weighed 3 lbs.(1.35 Kg.) complete which is even with maximum allowable weight.

APPENDIX "A"

YORK RESEARCH, INCORPORATED

TEST REPORT

TEST REPORT NO. 6-2218-00A

DATE August 24, 1976

REPORT OF TEST

FRANGIBLE APPROACH LIGHT

for

SEPCO DIVISION
CONNECTICUT INTERNATIONAL CORPORATION

YORK RESEARCH CORPORATION
ONE RESEARCH DRIVE
STAMFORD, CONN. 06904

	PREPARED	CHECKED	APPROVED
BY	B.J.Corcoran	H.T.Dennis	G.T.Ciccone
SIGNED	B.J.Corcoran	H.T.Dennis	G.T.Ciccone
DATE	8/25/76	8-25-76	8-25-76

Administrative Data

1.0 Purpose of Test: To subject the submitted Frangible Approach Lights to Environmental testing in accordance with the test procedures of this report.

2.0 Manufacturer: Connecticut International Corporation
Sepco Division
Windsor Locks, Connecticut 06096

3.0 Manufacturer's Type or Model No.: P/N 40740
P/N 40740-R

4.0 Drawing, Specification or Exhibit: PUrchase Order No. 40435
C.I.C.Document No. 7511, Rev. B

5.0 Quantity of Items Tested: Two (2)

6.0 Security Classification of Items: Unclassified

7.0 Date Test Completed: August 18, 1976

8.0 Test Conducted By: YORK RESEARCH CORPORATION

9.0 Disposition of Specimens: Returned to Client

10.0 Abstract: The Frangible Approach Lights completed the Environmental testing with the results as detailed in the Results Section of this report.

DATE August 24, 1976

REPORT NO. 6-2218-00A

LIST OF EQUIPMENT

ITEM	MANUFACTURER	MODEL NO.	CALIBRATION DATE	CALIBRATION DUE DATE
Humidity Chamber	York Research	Y-302	2/18/76	8/18/76
Salt Spray Chamber	Industrial Pump & Filter Mfg. Co.	Y-317	7/6/76	1/6/77
Temperature Chamber	Bethlehem	Y-2021	6/10/76	12/10/76
A.C. Ammeter	Weston Instrument	433	3/5/76	9/5/76
Spray Nozzle	Spraying Systems of Illinois	MIL-Spec.	Prior to Use	

HUMIDITY TEST

Test Procedure

The Frangible Approach Lights were placed in the Humidity chamber in a manner simulating installed conditions. The test chamber was vented to the atmosphere to prevent pressure build-up. Prior to the start of the test the chamber temperature was between 68° and 100°F with uncontrolled humidity. The air velocity throughout the test area was less than 150 feet per minute.

Step 1 - The chamber temperature was gradually increased to 71°C and the relative humidity to 95% over a period of two (2) hours.

Stpe 2 - The conditions of 71°C and 95% relative humidity were then maintained for an additional six (6) hours.

Step 3 - The chamber temperature was then reduced over a sixteen (16) hour period to 28° ± 10°C while maintaining a relative humidity of 95% or greater.

Step 4 - Steps 1, 2 and 3 were repeated nine (9) times for a total of ten (10) cycles.

Step 5 - The test items were then removed from the chamber and operated at a test current of 20 amps and visually inspected.

Test Results

There was no evidence of any physical/mechanical damage as a result of the Humidity test. Both lamps operated satisfactorily at a current of 20 amps.

SALT SPRAY TEST

Test Procedure

The Frangible Approach Lights were tested in accordance with Federal Test Method 151, Method 811, for a time period of twenty-four (24) hours. The male end of the power cord was covered during this test.

The test items were suspended by nylon cord inside the Salt Spray chamber in their normal operating position. The chamber was then sealed and the chamber temperature increased to, and maintained at, +95°F for a period of twenty-four (24) hours. During the twenty-four (24) hour period, the units were subjected to the specified Salt Spray Fog.

The Salt Spray Fog was produced using a 5% solution prepared by dissolving five (5) parts by weight of sodium chloride in ninety-five (95) parts by weight of distilled water.

The sodium chloride contained on the dry basis, not more than 0.1% of sodium iodide and not more than 0.2% of total impurities. The solution was adjusted to and maintained at a specific gravity between 1.026 and 1.041 and at a pH value between 6.5 and 7.2 when measured at a temperature of +95°F.

Following the twenty-four (24) hour exposure period the test units were removed from the chamber. The exterior surfaces were wiped to remove excess moisture.

Test Results

There was no evidence of corrosion or exterior deterioration. The Post-Salt Spray Electrical test was satisfactory when a test current of 20 amps was applied to each of the test items.

THERMAL SHOCK TEST

Test Procedure

The Approach Light Assemblies were energized at a test current of 20 amps for a time period of 60 ± 10 minutes.

At the completion of the one (1) hour period, 4°C water was sprayed on the surface of the lamp housing for a time period of two (2) minutes. The diameter of the spray measured at the surface of the test item, was twelve (12) inches when applied from three (3) feet above the test item. The rate of flow was equal to 5" ± 1" per hour. Both assemblies were subjected to the above conditions.

Test Results

There was no evidence of any physical damage as a result of the Thermal Shock test.

CORROSION

A visual inspection was made of both assemblies after the Humidity and after the Salt Spray tests. There was no evidence of corrosion or malfunction of any mechanical part.

HIGH TEMPERATURE TEST

Test Procedure

The High Temperature test was conducted in accordance with Paragraph 3.3.1 of Document No. 7511.

The Approach Light assemblies were placed in the test chamber, connected through a port to the test equipment outside the chamber, and the chamber temperature was increased to 55°C (131°F). The chamber temperature was maintained at 55°C for one (1) hour and the relative humidity was less than 15%. While the chamber temperature was at 55°C, the lamp assemblies were energized for one (1) hour at a test current of 20 amps.

The lamp assemblies were visually inspected at the completion of the test for deterioration and malfunction.

Test Results

The assemblies functioned normally during the test. There was no evidence of deterioration or malfunctions as a result of the High Temperature test.

LOW TEMPERATURE TEST

Test Procedure

The Low Temperature test was conducted in accordance with Paragraph 3.3.2 of Document No. 7511.

The Approach Light assemblies were placed in the test chamber, connected through a port to the test equipment outside the chamber, and the chamber temperature was then decreased to -55°C (-67°F) and maintained for one (1) hour. While at -55°C, the lamp assemblies were energized for one (1) hour at a test current of 20 amps.

The lamp assemblies were visually inspected at the completion of the Low Temperature test for deterioration and malfunctions.

Test Results

The assemblies functioned normally during the test. There was no evidence of deterioration or malfunctions as a result of the Low Temperature test.